AD NUMBER

AD862742

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AUTHORITY

AFRPL ltr 29 Sep 1971

AFRPL-TR-69-43

PERFORMANCE OF VERTICAL TEST CELL 1-42B DURING EVALUATION OF A RESTARTABLE SOLID PROPELLANT MOTOR

John Denker

TECHNICAL REPORT AFRPL-TR-69-43

January 1969

AIR FORCE ROCKET PROPULSION LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
EDWARDS, CALIFORNIA

AFRPL-TR-69-43

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FOREWORD

The research firings described in this report were authorized as a part of Project 305803ARX conducted by the Liquid Rocket Division of the Air Force Rocket Propulsion Laboratory. The test item was designed and fabricated by the Thiokol Chemical Corporation under contract to the U.S. Army and project personnel of the Solid Rocket Division were responsible to coordinate testing activities at the Rocket Propulsion Laboratory with the Army requirements. Test firings were completed in Vertical Test Cell 1-42B during December 1968. This motor was the second of two motors (AMV7A and AMV7B); the first motor was fired in August 1968 and reported in September 1968. Mr. John Denker, RPRO; Lt R. Quintana, RPM, and Mr. Howard MacIntosh of Thiokol were the project engineers. Motor performance will be reported by Thiokol.

This technical report was prepared by

JOHN DENKER, RPRO
Project Engineer

ABSTRACT

Rocket propulsion system elements may perform differently in the low pressure of the space environment than during sea level firings and it is imperative that the behavior of the propulsion system in space be known prior to its use in space missions. These research firings were conducted to prove this Army-Thiokol research motor will start and stop on command in the space environment using igniters of a new design. VTC 1-42B which is evacuated by a steam-driven, 2-stage, ejector-diffuser system was used to simulate pressure altitudes up to 120,000 feet. Two firings of this motor (AMV7B) were performed because on the first firing the igniter failed to function as intended and the second test was required to obtain added information on reliability of this component. All components of the Vertical Test Facility performed satisfactorily, which resulted in simulated altitudes above 100,000 feet during the firing of the rocket motor.

NOMENCLATURE

A_d	Area, Diffuser Inlet, in^2
A_*	Area, Rocket Nozzle Throat, in^2
H	Pressure Altitude, feet
F.S.	Fire Switch = Rocket Ignition Time
P_c	Pressure, Cell, psia
P_t	Pressure, Total, psia
P_{de}	Pressure, Diffuser Exit, psia
RPRO	Test Operations Branch, Liquid Rocket Division, Air Force Rocket Propulsion Laboratory
RPM	Solid Rocket Division, Air Force Rocket Propulsion Laboratory
VTC 1-42B	Vertical Test Cell 1-42B of Air Force Rocket Propulsion Laboratory

I. INTRODUCTION

An Army-Thiokol developed rocket motor, intended for use in space propulsion systems, was fired in the simulated space environment of Vertical Test Cell 1-42B to determine if this motor design will start-stop thrusting on command in the low pressure environment of space. Several signals to start thrusting and several signals to terminate thrusting were sent to the motor to establish reliability of reaction for the design and measurements of delivered thrust and of nozzle dimensions made to establish delivered impulse and to measure durability of the mechanical components.

One of the three available ejector systems was used to maintain pressure in the test cell equal to that at 100,000+ feet altitude. Motor and cell parameters were recorded on digital tape systems and on direct-inking recorders.

II. FACILITIES UTILIZED

Data was recorded in digital format on a 192 channel Consolidated Systems Corporation tape recorder, in analog form on direct-inking Westronics recorders, and in analog form on a 36 channel Consolidated Engineering Corporation oscillograph. One 2-stage ejector system, driven by steam, and a 24-inch diameter cylindrical diffuser, which was driven by the rocket motor gas, evacuated the test cell of gases to provide the requested 70,000+ feet minimum pressure altitude. Thrust and pressures were sensed by strain-gage type transducers which were energized by direct current. The thrust mount and force measurement system were evaluated prior to use for this series of tests and found to be repeatable to .30% at the 90% confidence level and pressure measurements are repeatable to .5%. The electrical signals which fired the rocket motor were recorded on tape in frequency modulated form on an Ampex (FR 1300) recorder.

III. SIMULATED PRESSURE ALTITUDES

Vertical Test Cell (VTC) 1-42B will produce pressure altitudes as high as 150,000 feet by use of an engine-driven diffuser in series with up to three, 2-stage, steam-driven ejector systems which operate in parallel. During the firings of the Army-Thiokol motor, one, 2-stage facility ejector and a cylindrical 24-inch diameter ejector-diffuser, which was driven by rocket gases, were used. Simulated altitude was held well above the minimum requested 70,000 feet and all facility equipment functioned properly. Figure I shows the history of the test facility pressures.

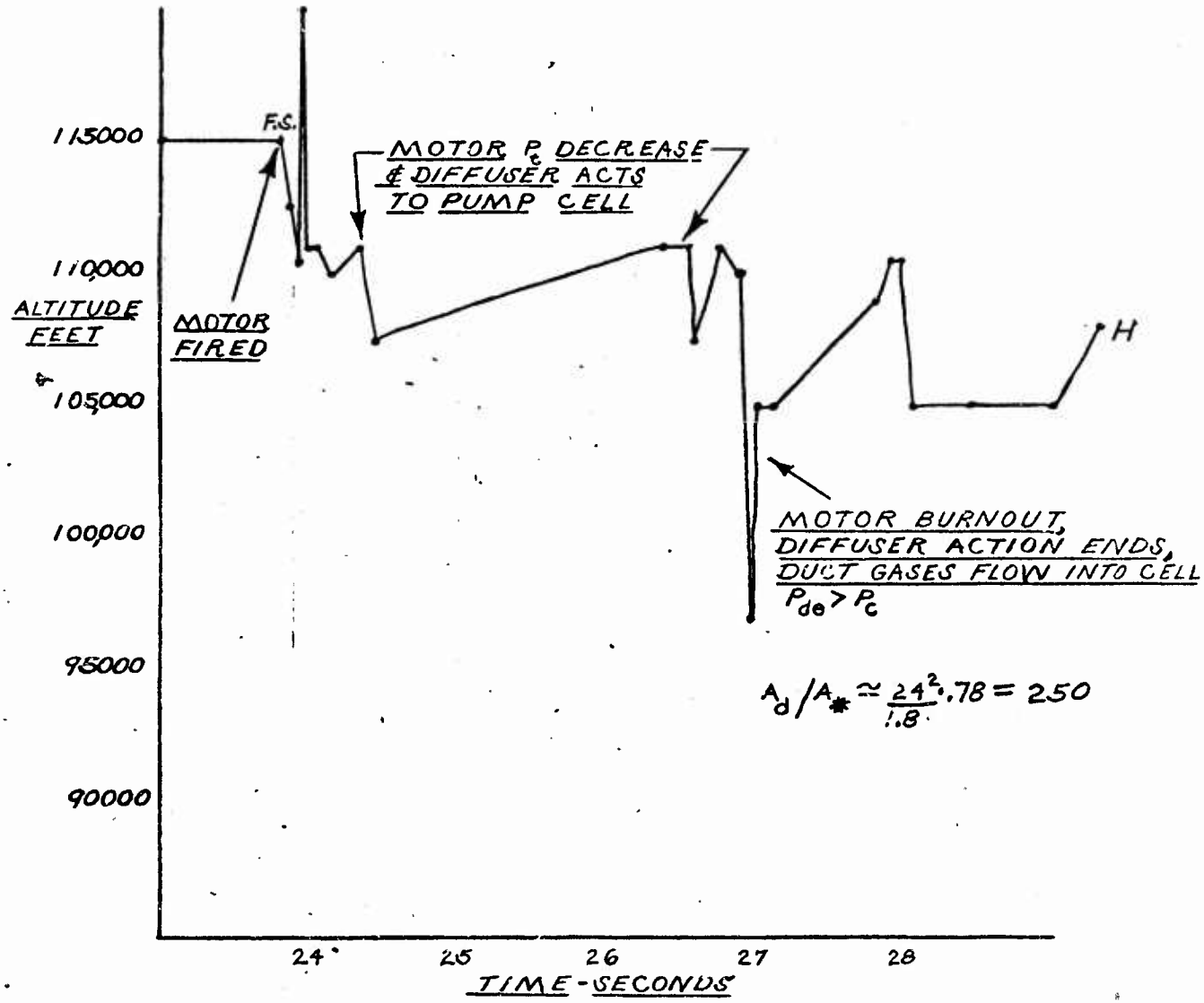

FIGURE I ALTITUDE SIMULATION BY I-42B

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IV. ABLATIVE MATERIALS AS THERMAL AND ABRASIVE PROTECTION FOR DIFFUSERS

The cylindrical diffuser used for these tests is a section of 24-inch water pipe which has no coolant jacket to aid in removal of heat energy. In a preceding firing of large motors into the 44-inch diameter water-cooled (jacketed) diffuser, rocket gases burned through the wall of the diffuser which prompted a search for a satisfactory thermal and abrasion barrier to be used as a protective coating for the diffuser inlet. Several materials were applied to the impingement area of rocket gases in the diffuser used in these tests. These included epoxy resin, a paste made by RPRO of epoxy resin and graphite particles, a V-61 rubber compound intended to be used as liner material for rocket motor cases, Saueresin which is a patented ceramic material, and an asbestos-resin material which was supplied by Haveg-Reinhold (Santa Fe Springs, California). The approximately five-second duration of each pulse of this test series did not provide as severe a heat and abrasion situation as the earlier motor firing. The materials were applied and reacted as listed below:

a. V-61 - troweled on - no measurable erosion.

b. Epoxy-carbon paste - troweled on - no measurable erosion.

c. Epoxy resin (only) - paint brush - no measurable erosion.

d. Sauresin - troweled on - no measurable erosion.

e. Asbestos-resin sheet - bolted - no measurable erosion.

The materials will be evaluated during firings in January-June 1969 which will impose more severe heat conditions because of longer firing durations up to 500 seconds.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
AFRPL
Edwards, California 93523

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP
N/A

3. REPORT TITLE

Performance of Vertical Test Cell 1-42B during Evaluation of a Restartable Solid Propellant Motor

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Test Report - December 1968

5. AUTHOR(S) *(First name, middle initial, last name)*

John Denker

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1969	8	None

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 3058	AFRPL-TR-69-43
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Air Force Rocket Propulsion Laboratory Air Force Systems Command, USAF Edwards, California

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DD FORM 1 NOV 65 1473

Unclassified

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT